CHAMBER FOR THE OPTICAL MANIPULATION OF MICROSCOPIC PARTICLES

This invention is the result of a contract with the Department of Energy (Contract No. W-7405-ENG-36).

BACKGROUND OF INVENTION

This invention relates to optical trapping and, more particularly, to the optical trapping of microscopic particles, such as biological cells, for manipulation and experimentation.

A laser beam can interact with microscopic particles to produce radial forces on a particle to trap the particle on the beam axis. These optical traps have been found effective for trapping biological particles, i.e., bacteria, viruses, cells, etc., for experimental manipulation. See A. Ashkin et al., "Optical Trapping and Manipulation of Single Cells Using Infrared Laser Beams," 330 Nature, pp 769-771 (December 1987), incorporated herein by reference. Infrared laser beams with sufficient power to move the biological particles through a surrounding medium do not appear to interfere with normal biological functions. A sample cell is provided with a hollow glass fiber for use in separating and removing selected particles from the sample cell. However, the fiber containing the selected cells must be physically removed from the sample cells for further experimentation.

In another application of optical trapping, a stream of particles is formed in a laser beam and transported through an interrogation chamber for selecting particles with predetermined properties. When a particle is identified with the desired property, a second laser beam acts to remove the particle from the transport beam for removal and subsequent experimental use. See U.S. patent application Ser. No. 07/126,156, filed Nov. 30, 1987, for "Laser Particle Sorter," now U.S. Pat. No. 4,887,721, issued Dec. 19, 1989, incorporated herein by reference.

It would be desirable to provide for experimentation on biological cells in a controlled and contained environment that can be suitably isolated from environmental contamination. Accordingly, it as an object of the present invention to provide a chamber that is suitable for biological particle optical manipulation and experimentation.

Another object of the present invention is to provide for introducing particles into a controlled environment for biological experiments.

Yet another object is to provide for optically introducing a plurality of biological particles into controlled compartments which can be selectively interconnected.

One other object is to provide a chamber with compartments that are connected for the introduction and circulation of cell and chromosome suspensions, culture media, and reagents.

Additional objects, advantages and novel features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

SUMMARY OF THE INVENTION

To achieve the foregoing and other objects, and in accordance with the purposes of the present invention, as embodied and broadly described herein, the apparatus of this invention may comprise a particle control chamber for use with a laser system for trapping and manipulating the particles. A manipulation chamber has a central section defining a plurality of inlet and outlet ports for the particles and for fluids used to control or to contact the particles. A plurality of flow channels connects the inlet and outlet ports and defines a manipulation area in the central section which is optically accessible by the laser system and an imaging system. The manipulation area further includes a first enlarged volume in selected first ones of the channels usable for introducing the particles, each said first volume being effective to contain a selected number of particles, and interconnection channels for selectively interconnecting the first enlarged volumes. In one particular embodiment, a second enlarged volume may be included in second ones of the channels usable for controlling a distribution of the particles and the fluids in the manipulation area, each said second volume being effective for trapping a flow control air bubble.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of the specification, illustrate the embodiments of the present invention and, together with the description, serve to explain the principles of the invention. In the drawings:

FIG. **1** is a pictorial illustration of a laser system according to the present invention.

FIG. **2** is a plan view of a central flow section.

FIG. **3** is an enlarged view of a manipulation area on the flow sheet shown in FIG. **2**.

FIG. **3A** is a schematic in partial cross section of electroded chambers in the manipulation area of FIG. **3**.

FIG. **4** is an isometric view of one window for covering a side of the flow sheet shown in FIG. **2**.

FIG. **5** is a cross section of an inner holder for supporting the flow sheet shown in FIG. **2**.

FIG. **6** is a pictorial illustration of an assembled inner holder and central flow sheet assembly.

FIGS. **7A** and **7B** are cross section views of the outer shell components for thermally controlling the inner holder and central flow sheet assembly shown in FIG. **6**.

DETAILED DESCRIPTION OF THE DRAWINGS

In accordance with the present invention, a particle manipulation chamber cooperates with a laser system for trapping microscopic particles. The manipulation chamber enables selected particles to be introduced into the chamber, selectively combined with other particles, and placed in a controlled environment, i.e., temperature, culture medium, reagents, etc., for conducting experiments. A disposable central section assembly provides a sterile environment for each experiment with no cross-contamination. An optical viewing system permits an operator to manipulate particles within the system and to view the progress of experiments within the chamber. As herein described, the manipulation chamber has the following functional characteristics: